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Study of the Nutritional Value of the Snail Achatina Achatina and Its Importance in Specific Dietary Regimes

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Abstract Snails are gastropods that belong to the Mollusca class. Among the many existing species, *Achatina achatina* is one of the most consumed. In order to ascertain whether these snails could be valorized and incorporated into specific dietary regimes, a study was conducted on the composition of their flesh. The objective of this study was to determine the nutritional composition of the flesh of this species of snail, specifically the proportion of macronutrients and micronutrients. The results demonstrated that the *Achatina achatina* species' flesh is a significant source of protein, with a percentage of 56.7, and a relatively low-fat content (3.2%). The fatty acid profile revealed the presence of unsaturated fatty acids, including palmitoleic acid, oleic acid (at a rate of 71.75%), linoleic acid (7.4%), and trace amounts of linolenic acid. Additionally, the mineral analysis demonstrated that for every 100 g of dry matter, this species of snail contains 143 mg of calcium, 116 mg of phosphorus, 121 mg of potassium, 5.65 mg of magnesium, and other minerals. Based on these findings, it can be concluded that the meat of the *Achatina achatina* snail could be incorporated into a variety of dietary regimes. The protein and mineral-rich mealworm flour could be used to fortify foods for children under five with protein-energy malnutrition and to promote their growth, as well as in the diets of individuals with mineral deficiencies. The presence of unsaturated fatty acids in this species of meat may be beneficial for individuals with cardiovascular disease, hypertension... It may also be included in the diet of individuals with psychiatric disorders, dermatological or rheumatological issues, and may contribute to the prevention of certain types of cancer.

Keywords: *snail, species achatina achatina, nutritional value, diet*

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1. Introduction

A healthy and balanced diet is perceived as the optimal remedy for humans, as it provides the essential nutrients required for optimal physiological functioning. These nutrients are classified as macronutrients and micronutrients. Among these nutrients are animal proteins, which, as the name implies, are derived from animal-based products such as meat, fish, eggs, dairy products, and others. Animal proteins occupy a significant role in our diet; however, certain populations lack access to them due to economic constraints. Statistical data from Ivory Coast indicate that in 2008, approximately 5% of the population encountered difficulties in accessing conventional animal proteins such as meat and fish [1]. In addition to conventional food resources, there are other locally available and highly regarded alternatives, including termites, caterpillars, and especially snails [2]. Indeed, snails are shelled invertebrates belonging to the class of gastropods, which are part of the phylum Mollusca. They exist all over the world and most are terrestrial, although others are aquatic. In Ivory Coast, they colonize the dense forests of the southern half [3]. Snails are highly valued for the quantity of meat they provide. Each year, approximately 1,900 tons of these mollusks are supplied to markets in Abidjan [4]. The portion of the body most commonly consumed is the pedal mass [5]. The shell and visceral mass may be valorized for use in animal nutrition [6]. The snail is an important source of protein, amino acids (lysine, phenylalanine, and leucine), energy, and minerals [5,7,8]. However, the lipid content of these mollusks is relatively low. It is therefore not surprising that it is recommended as a dietary supplement in low-fat diets [9]. Additionally, these snails are employed in traditional, modern, and cosmetic medicine [10]. However, given the differing chemical compositions of different species of snail, it is important to ascertain the nutritional value of these mollusks. In order to contribute more effectively to their valorization in the context of nutritional rehabilitation of vulnerable populations, a study is being conducted on the species *Achatina achatina*, which is one of the most consumed. The objective of this study is to determine the nutrient composition of the snail meat in order to propose it as a food ingredient in specific dietary regimes.

2. Materials and Methods

Biological Material

The biological material used in this study is the flesh of the *Achatina achatina* species of snail. The snails were procured from the Abidjan (Ivory Coast) market, more specifically from the Adjamé commune. They originated from Agboville, a locality situated in the southeastern region of Côte d'Ivoire and encompassed by the Agnéby-Tiassa region.

Methods

Preparation of snail flour

Once purchased, the snails are washed before being removed from their shell. The resulting meat is weighed and then dried in an oven set to 80°C for 72 hours. The resulting dry sample is ground and passed through a sieve, producing a fine powder, which is the snail flour.

Determination of dry matter

The dry matter is determined according to the AOAC method [11]. This method consists of cutting the snail flesh into small pieces and subjecting them to drying at 80°C until a constant weight. This allows the dry matter content and the percentage of moisture to be calculated.

Determination of ash content

The principle of determining the ash content is based on the AOAC method [11]. The sample is incinerated in a muffle furnace at 520°C for 48 hours to eliminate organic matter. The quantity of ash obtained is measured and transcribed as a percentage of the initial sample weight.

Determination of protein content

The principle is based on the Kjeldahl method, which comprises two principal stages: sulfuric mineralization or digestion and subsequent distillation, followed by analysis [12].

Determination of lipid content

The fat extraction process from snail flour is conducted in accordance with the AFNOR method [13], which employs the Soxhlet apparatus. The resulting yield of extracted fat is expressed as a percentage of the fat content in 100 g of snail flour.

Determination of iodine index

The iodine index is defined as the number of grams of iodine fixed per 100 g of fats. This is determined according to the Wijs' method [14]. In accordance with the experimental protocol employed, an excess of iodine chloride, designated the Wijs reagent, is added to the fat solution in chloroform. Following a brief reaction period, potassium iodide and distilled water are introduced. The released iodine is then quantified using a sodium thiosulfate solution (0.1 N) in the presence of starch paste

Determination of mineral elements

The mineral elements are quantified through atomic absorption spectrophotometry, equipped with an air-acetylene burner in accordance with the CEE-BIPEA reference method [12]. The minerals are quantified directly in the diluted wine by atomic absorption spectrophotometry, after the addition of a spectral buffer of cesium chloride to prevent mineral ionization.

Determination of fatty acid profile

The fatty acid profile is determined by the Morrison and Smith technique, which employs a gas chromatography coupled with a mass spectrometer (CPG-SM) [15]. In accordance with the aforementioned principle, a 50 g portion of the flour is weighed using a precision balance and subsequently dissolved in 500 ml of solvent (Ethanol/water 70: 30 v/v). The entire apparatus is then transferred to an Erlenmeyer flask of 500ml capacity and subjected to ultrasonication for a period of two hours, with continuous agitation. Following this, the mixture is left to macerate for a further 24 hours. The resulting extract is filtered twice through cotton. The filtrate is then evaporated to obtain residues that are subjected to subsequent analysis. The results are expressed as a percentage of total identified fatty acids. The initial temperature was 150°C, with a gradient of 1.3°C per minute until 220°C, 40°C per minute until 260°C (for five minutes), resulting in a total analysis time of 59.8 minutes.

Statistical analysis

The data collected were analyzed and processed using STATISTICA 7.1 software. The mean comparisons were conducted using the Newman-Keuls test, with a 5% significance level.

3. Results

The results, which provide the dry matter, humidity, ash, protein, lipid content, as well as the iodine index, of the snail meat, are presented in Table 1. With an estimated humidity content of 79.2% and a dry matter content of 20.8%, the meat of the *Achatina achatina* snail contains a minimal amount of fat (3.2%). However, this species of snail is particularly rich in protein, with a rate of 56.7%. The iodine index is estimated to be 5.92.

Table 1. Dry matter, humidity, ash, protein, lipid and iodine index of snail flesh

Constituents	Contents (g/100g of dry matter)
Dry matter	20.8 ± 0.2
Humidity	79.2 ± 0.2
Ash	6 ± 0.2
Lipid	3.2 ±0.2
Protein	56.7 ±0.17
Iodine index	5.92 ±0.17

In order to evaluate the nutritional value of the *Achatina achatina* snail, the profile of fatty acids was determined. The results presented in Table 2 demonstrate that this species of snail contains saturated, monounsaturated, and polyunsaturated fatty acids. With the exception of palmitic acid, which is present in varying quantities (12.6%), the snail's flesh contains trace amounts of saturated fatty acids. The respective percentages of the acyl groups in the fatty acids are as follows: 0.85% for myristic acid, 1% for behenic acid, and 4.75% for stearic acid. However, unsaturated fatty acids are present in sufficient quantities: 71.75% oleic acid, 7.4% linoleic acid, 1.15% palmitoleic acid, and 0.25% linolenic acid.

Table 2. Fatty acid profile of the species *Achatina achatina*

Fatty acids	Contents (%)
Myristic acid	0.85±0.07
Palmitic acid	12.6 ± 0.141
Stearic acid	4.75± 0.07
Behenic acid	1±0
Palmitoleic acid	1.15±0.07
Oleic acid	71.75±0.35
Linoleic acid	7.4±0.14
Linolenic acid	0.25±0.07

With regard to mineral content, the results demonstrate that the species *Achatina achatina* represents an excellent source of calcium, phosphorus, and potassium, with respective levels of 143%, 116%, and 121%. Additionally, the sample contains magnesium (5.65%), iron (1.35%), sodium (2.3%), and manganese (2.95%). However, the rates of copper and zinc are negligible (Table 3).

Table 3. Dosage of mineral elements in the flesh of the species *Achatina achatina*

Mineral elements	Contents (g/100g of dry matter)
Calcium	143 ± 1.41
Copper	0.015 ± 0.007
Phosphorus	116± 1.41
Manganese	2.95 ±0.21
Zinc	0.01±0
Iron	1.35 ±0.21
Sodium	2.3±0.14
Potassium	121±1.41
Magnesium	5.65±0.21

4. Discussion

The results of this study demonstrate that the meat of the *Achatina achatina* species is an excellent source of protein, with a protein content of 56.7%. This value is greater than the protein content of the *Limicolaria flammea* species (48.63%) as reported by Séa *and col.* [16] and the *Archatina marginala* snail, for which the estimated protein content is 20.50% [17]. The protein content of the *Achatina achatina* snail in our study is also higher, but more similar to that of the *Achatina fulica* snail (51%) [18] and the *Pila Leopoldvillensis* snail (53.2%) [19]. This demonstrates that the protein content of snails varies between species. This variation in protein content may be attributed to the alteration of edaphoclimatic conditions in the diverse habitats of these gastropods. The high protein content of snails is likely due to the fact that their flesh is primarily composed of muscle tissue. As a valuable source of animal protein, snails could be utilized as a protein source in the form of flour to enrich the diets of weaned infants in forest areas to prevent protein-energy malnutrition in children under the age of five. The primary function of a dietary protein is to meet the body's need for nitrogen and essential amino acids [20]. Food sources of protein provide a range of nutrients beyond protein, contributing significantly to the nutritional adequacy of our diet [21].

A considerable body of research [7,8,22] has indicated that these animals represent a significant source of protein, although their meat is relatively low in fat. As indicated in Table I, the fat content of snail meat is relatively low (3.2%), which corroborates the findings of Murphy [23]. The consumption of snail meat may contribute to a reduction in the prevalence of non-transmissible food-related illnesses. Indeed, non-transmissible diseases such as diabetes, hypertension, and other cardiovascular diseases are caused by excessive consumption of saturated fat-rich foods, particularly those of animal origin, coupled with a lack of physical activity. The iodine index of the escargot meat fat is greater than zero (5.92). This value indicates the presence of unsaturated fatty acids. Indeed, in the analysis of fat, the iodine index is the most useful constant, as it is from these values that the oil's dryness can be determined. Therefore, the more unsaturated an oil is, the higher its iodine value [13], which can be used to assess the oil's susceptibility to rancidity. This is because unsaturated oils are more susceptible to oxidation due to the presence of double bonds, which allow the oil to interact with oxygen more readily. With regard to the degree of unsaturation, the fatty acid profile indicates that the species *Achatina achatina*, despite its low lipid content, contains unsaturated fatty acids. Oleic acid is the most abundant fatty acid, with an estimated content of 71.75%. Additionally, the snail contains linoleic acid, with a concentration of 7.4%. Indeed, linoleic acid is a polyunsaturated fatty acid. Its distinctive feature is that it is the sole essential fatty acid, meaning that it cannot be synthesized by the body, which underscores its significance in nutrition. Consequently, numerous studies have demonstrated that unsaturated fatty acids, particularly the polyunsaturated omega-3, are involved in the development and maintenance of various organs, including the brain and its cognitive functions [24]. Additionally, they may play a role in the prevention and treatment of various pathologies, including ischemic cardiovascular disease, inflammation, psychiatric disorders, dermatological conditions, rheumatological disorders, and even certain types of cancer. [25].

In regard to minerals, the ash content of a dietary sample provides an indication of the number and quantity of minerals present. The snail's diet comprises a variety of food sources, including soil, which may explain the relatively high ash content (6%) observed in the *Achatina achatina* snail powder obtained in this study. However, this value is slightly lower than that of the black varieties (9.86%) and white varieties (9.83%) [26]. While the calcium content of meat and offal is typically low (9 to 11 mg/100 g), with high absorption rates by the body [27,28], it is important to note that It is not possible to make a similar assertion regarding the meat of the *Achatina achatina* snail, however, as the mineral analysis revealed a relatively high calcium content of 143 mg/100 g dry matter. Indeed, calcium was identified as the most abundant mineral present in the flesh of the species *Achatina achatina*. Calcium is essential for normal blood clotting [29], which may explain the use of snail extract to stop bleeding from wounds. A reduced calcium blood level can cause increased irritability of the nervous system, while a very low calcium level may result in convulsions [29,30]. The incorporation of snail meat, in the form of flour, into weaning foods may also be advisable, given the high calcium requirements during childhood, when skeletal growth is occurring [31].

With regard to phosphorus, the content is 116 mg/100 g of dry matter in the species *Achatina achatina*. Indeed, phosphorus fulfills a multitude of functions within the body that are unique among mineral elements. It forms a complex with calcium, thereby conferring rigidity to the bones and teeth. Approximately 80% of the phosphorous in the body is found in skeletal tissue [32]. Phosphorus functions as a mineral phosphate, which is essential for the growth and development of bones and teeth [33]. It serves as a cofactor for numerous enzymes and activates several B complex vitamins. Insufficient intake of phosphorus results in abnormally low serum phosphate levels, a condition known as hypophosphatemia. The clinical manifestations of hypophosphatemia include loss of appetite, anemia, muscle weakness, bone pain, rickets (in children) and osteomalacia (in adults), increased susceptibility to infection, numbness and tingling in the extremities, and difficulty walking. A severe hypophosphatemia can result in mortality [33]. This underscores the vital role of phosphorus in the body. Consequently, the consumption of this species of snail may be a crucial intervention for individuals with deficiencies in this mineral.

Additionally, the flesh of the *Achatina achatina* species is rich in potassium, with a value of 121 mg/100 g of dry matter. This value is nevertheless inferior to that of the species *Limicolaria flammea*, which has a potassium content of 199.07 mg/100 g dry matter [16]. In 2005, the potassium content was also determined for this same species, *Achatina achatina*, in Nigeria, resulting in a value of 193.74 mg potassium per 100 g dry matter [7]. The discrepancy in potassium levels among the same species may be attributed to various factors, including the origin of the snails, climate change, and soil conditions from 2005 to the present. Potassium is a vital mineral for humans, as it plays a crucial role in the functioning of the nervous, cardiovascular, and muscular systems. This significant potassium source may be beneficial for individuals experiencing hypokalemia. Indeed, hypokalemia is characterized by a deficiency of potassium in the body, which can have severe consequences, including cardiac arrhythmia and urinary frequency. With regard to magnesium and iron, the respective concentrations obtained were 5.65 mg and 1.35 mg/100 g of dry matter. Additionally, magnesium serves as a cofactor in over 300 enzymatic reactions, making it a crucial element for the synthesis of carbohydrates, lipids, nucleic acids, and proteins, as well as for other functions in various organs of the cardiovascular and neuromuscular systems [34].

The mineral elements can be classified into two principal groups according to their concentration in the human body: macroelements and microelements [35]. Macroelements, or major minerals, require an intake of approximately 1 mg per kilogram of body weight per day. Such minerals include calcium, phosphorus, potassium, and magnesium. All macroelements are essential minerals, as deficiencies or excesses can lead to adverse effects on the body. The remaining elements, known as trace elements, require only a few milligrams per day. One may cite the following elements: copper, zinc, iron, cobalt… [36,37]. Indeed, the World Health Organization (WHO) has established that the recommended daily intake of calcium is between 800 and 1,000 mg, magnesium between 300 and 500 mg, phosphorus between 800 and 1,200 mg, iron between 1 and 3 mg, and protein between 70 and 105 g, with variations based on age and the sex of the individual [38]. It can therefore be posited that the flesh of the common snail (Achatina achatina) may be incorporated into dietary regimes as a means of rectifying deficiencies in mineral intake.

5. Conclusion

The results of this study demonstrate that the flesh of the species *Achatina achatina*, like that of other species of snails, is a rich source of nutrients. The nutritional composition of this gastropod has been determined, and it has been established that the *Achatina achatina* species is an important source of protein, containing up to 56.7% protein by weight. Additionally, the flesh is rich in minerals, including calcium, phosphorus, potassium, magnesium, and iron. Despite its low-fat content, the flesh of this species of snail contains monounsaturated and polyunsaturated fatty acids, namely palmitoleic acid, oleic acid, linoleic acid, and linolenic acid. The highest proportion of oleic acid was observed at 71.75%. Based on these findings, it can be posited that the meat of the *Achatina achatina* snail could be incorporated into a variety of dietary regimens. Given its high protein and mineral content, snail flour could be used to fortify foods for children under five years of age suffering from protein-energy malnutrition, as well as for all children undergoing growth. Additionally, *Achatina achatina* could be incorporated into the diet of individuals with mineral deficiencies. The presence of unsaturated fatty acids in this species of snail makes it a potentially beneficial food for individuals with metabolic disorders, including cardiovascular disease, hypertension, and other conditions. Additionally, the consumption of *Achatina achatina* snails may be beneficial for individuals with psychiatric, dermatological, or rheumatological disorders, as well as for cancer prevention.

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